A NEW RECTANGULAR WAVEGUIDE TO COPLANAR WAVEGUIDE TRANSITION

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ABSTRACT

A new rectangular waveguide to coplanar waveguide transition is described. The transition uses a ridge in one of the broad walls of the waveguide and a nonradiating slot in the opposite wall to split and rotate the electromagnetic fields of the rectangular waveguide TE10 mode into the CPW fields.

INTRODUCTION

Coplanar waveguide (CPW) is an attractive transmission line for microwave integrated circuits since the ground planes are on the same side of the substrate as the conducting strip (1). This permits the integration of both series as well as shunt circuit elements without the need for back side processing and via holes. A second important advantage of CPW which has recently emerged is in the design of microwave probes for on-wafer characterization of field effect transistors and for fast, inexpensive evaluation of microwave integrated circuits (2).

In order to fully utilize these advantages, transitions between CPW and other microwave transmission media are required. A coaxial connector to CPW transition in which the center pin and the ground connection of the coaxial connector make contact with the CPW center strip and ground planes respectively has been demonstrated at 18 GHz (3). By reducing the diameter of the coaxial connector, the upper frequency of these transitions has been extended to 50 GHz. Further reduction of the coaxial connector dimensions to increase the frequency of operation may be limited by the fragility of the connectors. Also, millimeter wave sources use rectangular waveguide at the output ports. Therefore, there is a need to develop rectangular waveguide to CPW transitions for applications at V-Band (50 to 75 GHz) and W-Band (75 to 110 GHz).

A waveguide to CPW transition has been reported by Bellantoni, et al. (4). The transition uses a finline taper to concentrate the electric fields and a wire bond to split the electric currents between the two ground planes. The difficulty with the design is positioning the wire bond such that the two slots are excited in equal magnitude and phase. A further difficulty with finline transitions is the occurrence of resonances created by the transition (4,5). This paper presents the design and characteristics of a new rectangular waveguide to CPW transition which uses a ridge in one of the broad walls of the waveguide and a nonradiating slot in the opposite wall. This arrangement transforms the rectangular waveguide TE10 mode into the CPW mode with equal magnitude and phase excitation of the slots. The transition is capable of providing full waveguide bandwidth.

TRANSITION DESIGN

Figure 1 is a schematic of the transition. The printed circuit board shown in Fig. 1(a) forms the bottom wall of the rectangular waveguide. On this printed circuit board, a nonradiating slot is etched which gradually tapers to a width equal to S + 2W, where S and W are the width of the CPW center strip and slot, respectively. The cosine tapered ridge shown in Fig. 1(b) protrudes from the top wall of the waveguide and extends down to the printed circuit board metalization at the end of the taper. The ridge width is matched to the width of the center strip conductor, S, of the CPW. The electric field distribution at cross sectional planes along the transition is illustrated in Fig. 2. One can easily visualize that the ridge and the nonradiating slot gradually split the electromagnetic fields of the TE10 waveguide mode and rotate them through 90° to match the fields of the CPW.

TEST RESULTS FOR K BAND TRANSITION

A transition has been designed for K band. The printed circuit portion of the transition has been fabricated on a 0.125 in. thick 5880 RT/Duroid substrate with single sided copper cladding. The ridged waveguide portion of the transition is copper. The cosine taper is 1.5 in. long or approximately 1.5 λ_g at the center frequency. The S and W of the CPW are 0.032 and 0.008 in. respectively yielding a 75 Ω transmission line. For testing, the two transitions were connected back to back through a 0.8 in. length of CPW transmission line. The characteristics for this transition are shown in Fig. 3. The return loss is greater than 11 dB

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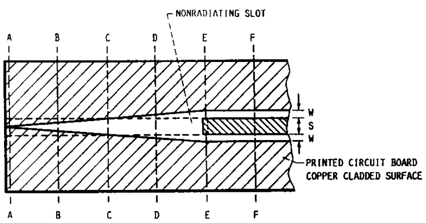
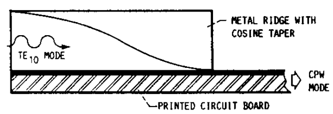
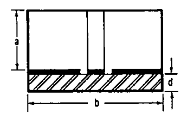


(a) PLAN VIEW ILLUSTRATING THE NONRADIATING SLOT IN THE BOTTOM WALL OF THE RECTANGULAR WAVEGUIDE.



(b) LONGITUDINAL VIEW ILLUSTRATING THE COSINE TAPERED METAL RIDGE.



(c) END VIEW.

FIGURE 1. - SCHEMATIC OF THE TRANSITION.

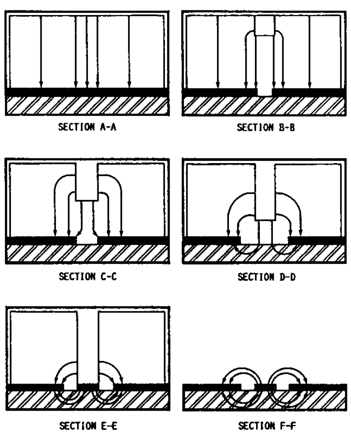
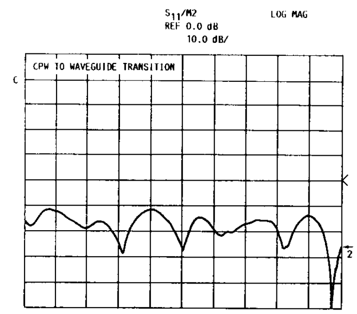
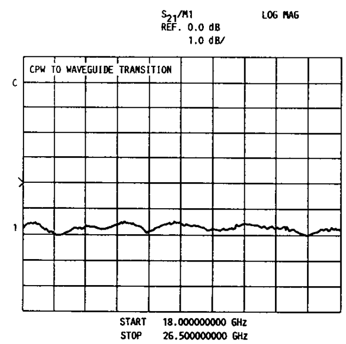


FIGURE 2. - ELECTRIC FIELD DISTRIBUTION AT VARIOUS CROSS-SECTIONS ALONG THE TRANSITION.



(a) INPUT RETURN LOSS AS MEASURED AT THE WAVEGUIDE PORT.



(b) MEASURED INSERTION LOSS OF TWO TRANSITIONS CONNECTED BACK TO BACK.

FIGURE 3.

across the band. The average insertion loss for the back-to-back transitions is 1.75 dB with 0.25 dB ripple.

CONCLUSIONS

A new rectangular waveguide to CPW transition has been developed with full waveguide bandwidth. This transition should permit the use of CPW based circuits in the millimeter wave frequency range and the development of microwave probes above 50 GHz for fast and inexpensive testing of the millimeter wave circuits.

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